NREL Capabilities

Aaron Andersen

ARPA-e Workshop

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Transforming **ENERGY** through computational excellence

1 Overview of Energy Systems Integration Facility (ESIF)

2 Lab Testing

3 Data Center Testing


Lab
Data Center
Office

Lab Testing

Optimization & Control Lab

Each “Building” station has:

- 480V, 3P, 400 A service (~330 kVA)
- 208V/3P also available in area

Fluid Conditioning Module

- Modulate flow and temperature
- Dump heat into ESIF research chilled water lines, ~100 tons (350 kW)

HVAC Systems Lab

Thermally isolated calorimeter to measure energy flows:
- Electric power in
- Thermal heat out

Eight Liquid Cooled Servers in Explorer Rack

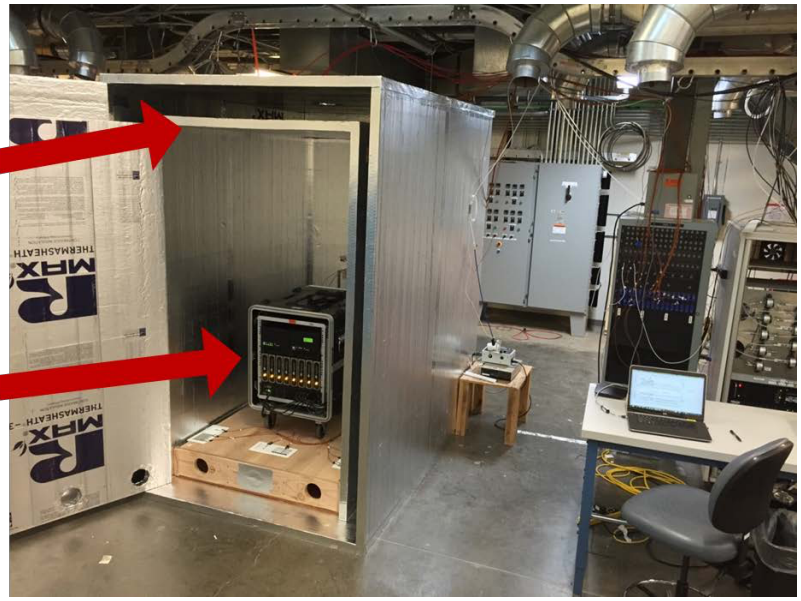


Figure 6. Eight LSS servers in compact rack, sitting inside a guarded calorimeter at NREL's Advanced HVAC Systems Laboratory
Photo by Eric Kozubal, NREL

Schematic of an Experimental Setup

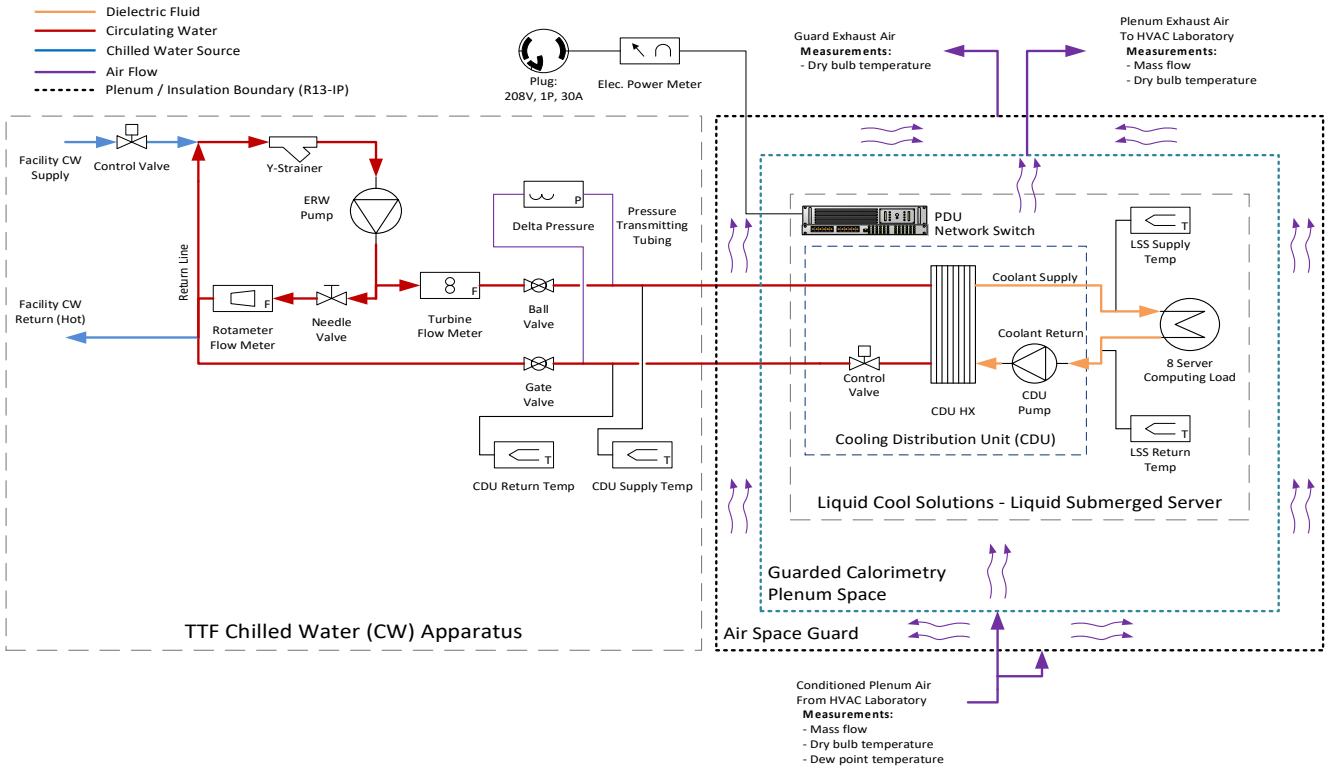


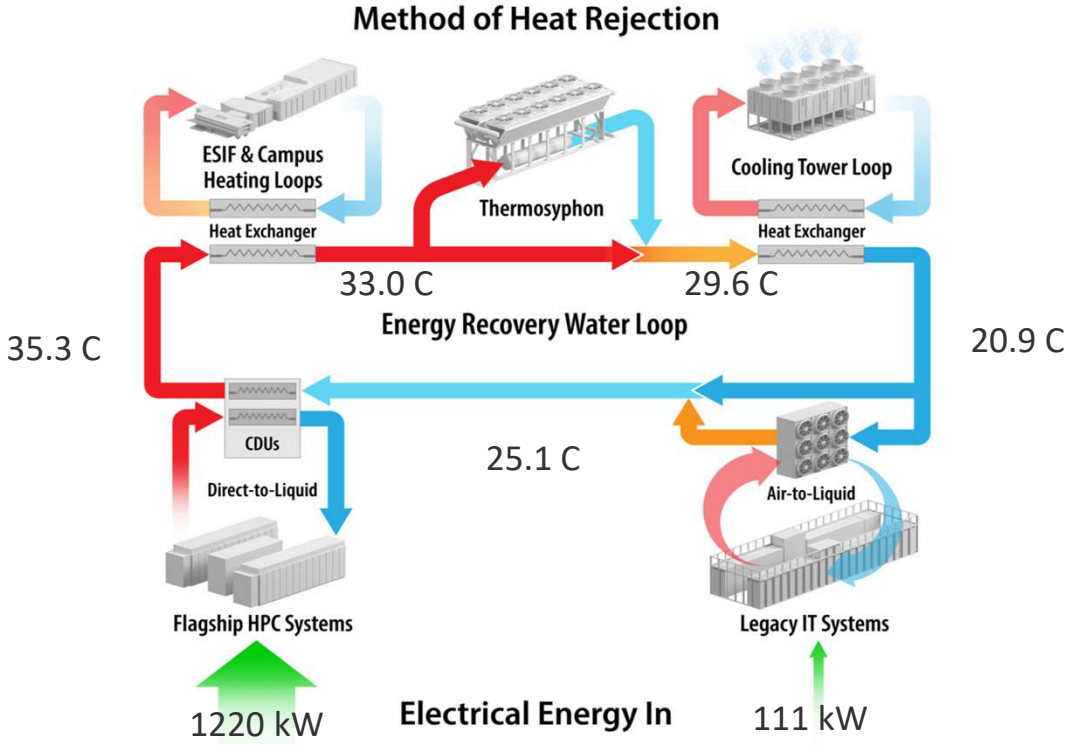
Figure 5. Process schematic showing fluid flows and sensors used to measure electrical and thermal power flows

ESIF Data Center

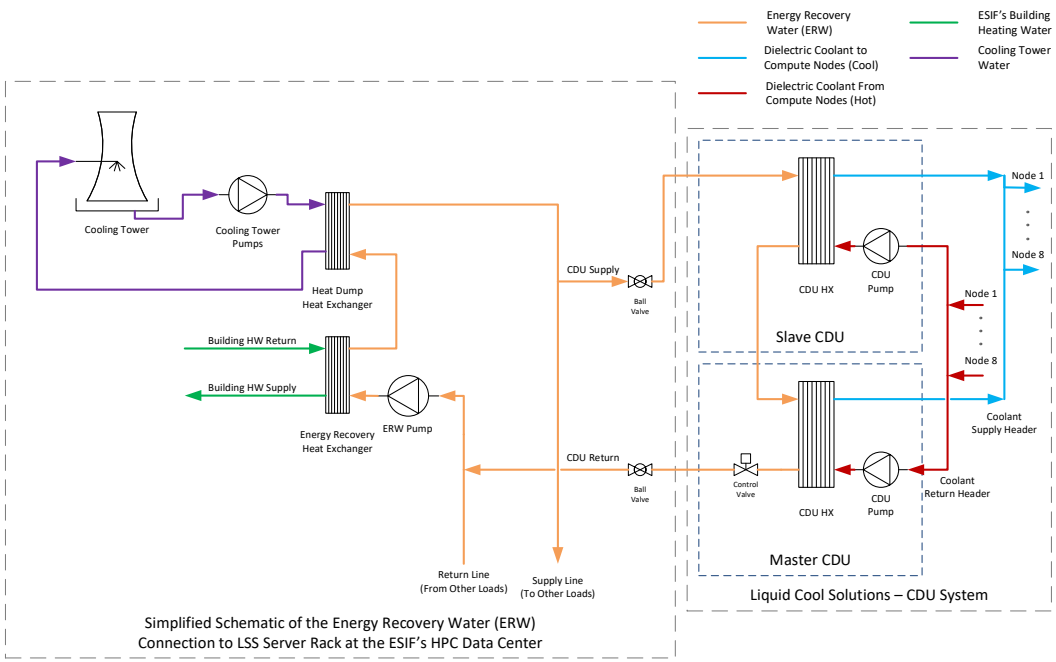
ESIF Data Center Cooling Diagram

Temperature and Electrical data from November 2021

- Predominantly direct-to-liquid cooling
- Thermosyphon (dry-cooler) has demonstrated savings of 6.5 Million Gallons in a 5-year period
- Heavily instrumented with timeseries data capture
  - Mechanical
  - Electrical
  - Computing/Storage Equipment
- Regularly achieve PUE of < 1.04
- Energy Recovery ERE mixed seasonal results



Example Data Center Evaluation



Simplified Schematic of the Energy Recovery Water (ERW) Connection to LSS Server Rack at the ESIF's HPC Data Center

Process schematic showing liquid flows of the LSS server rack installed at NREL's HPC data center at the ESIF. A more detailed schematic can be found in Appendix F: HPC Data Center Cooling Overview Schematic. In this diagram, the LSS system is located at "Other Liquid Systems."

March 21, 2016 - Eric Kozubal, NREL, Harsh Patel and Daryl Lautenschlager, work on the LiquidCool Solution's ""Liquid Submerged Server"" at ESIF's HPC data center. (Photo by Dennis Schroeder / NREL)

Resources

- Innovation Incubator: LiquidCool Solutions Technical Evaluation Laboratory Study and Demonstration Results of a Directed-Flow, Liquid Submerged Server for High-Efficiency Data Centers
  - www.nrel.gov/docs/fy18osti/70459.pdf
- Thermosyphon
  - Results from 24 Months: www.nrel.gov/docs/fy18osti/72196.pdf
  - Modeling and Installation: www.nrel.gov/docs/fy17osti/66690.pdf
- Energy Performance Evaluation of Aquila's Aquarius Fixed Cold Plate Cooling System at NREL's High Performance Computing Center
  - www.nrel.gov/docs/fy19osti/73356.pdf
- Energy Performance Testing of Asetek's RackCDU System at NREL's High Performance Computing Data Center
  - www.nrel.gov/docs/fy15osti/62905.pdf
- NREL Modeling and Analysis Capabilities
  - Techno-Economic Analysis (REopt) reopt.nrel.gov/about/index.html
  - Modeling District Heat (URBANopt) www.nrel.gov/manufacturing/district-energy-systems.html

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